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RECENT DEVELOPMENTS IN AGRICULTURAL SCIENCE.[1]

IN dealing with the science applied to a particular industry like agriculture it is convenient to draw a distinction between the class of investigations which seem to be contributions to knowledge pure and simple and those which aim at an immediate bearing upon practice. Both must be regarded as equally 'pure' science, since both should call for the same qualities of imagination and exact reasoning which characterize true scientific work; but while the one may appeal readily to the intelligent practical man, the value of the other can only be appreciated by the expert. The dividing line between these two branches of the subject is never a sharp one; indeed the most abstract and remote investigations are always cutting into the region of practise in a wholly unexpected fashion; but still the distinction I have indicated can be readily felt. To take an example—for the proper interpretation of many questions connected with the texture of soils and their behavior under cultivation—it is necessary to arrive at a clearer understanding than we now possess of the intimate causes which lead the finest particles of material like clay to unite together into floccules, or coagula, under the influence of traces of dissolved salts. Such investigations will touch upon some of the most debatable ground belonging to the theory of solutions and the constitution of matter, and can never be made intelligible to the

[1] Read at the South Africa meeting of the British Association for the Advancement of Science.

practical man himself; yet a knowledge of their results may be indispensable to the expert whom he consults about the character or management of his land, however trivial and workaday the actual question may seem.

In any agricultural experiment station worthy of its name, place should be found for investigations of this latter class; unfortunately many such institutions are under the necessity of showing 'results' which immediately appeal to the practical man and may be taken to justify the expenditure of public money; so that it is only by side issues, as it were, and by degrees, as the general public can be brought to trust its scientific men, that such work will be undertaken.

It is not my purpose, however, to deal to-day with this form of abstract research. I rather propose to point out certain lines of work in agricultural science which are now being pursued with increasing vigor, and which, from the very outset, promise to have considerable applications in practical life.

It is in the domain of agricultural bacteriology that perhaps the greatest progress has been recently made, in the main progress in connection with that perennial problem—the sources of the nitrogen of vegetation. From the very beginnings of agricultural chemistry, which we may very well date from the publication of De Saussure's 'Recherches Chimiques sur la Végétation' in 1804, discussion has raged round this point. Liebig, in his famous report to this association in 1842, regarded the atmosphere as the source of the nitrogen contained in the plant; but in the long controversy that followed, the view finally prevailed that the plant was only able to utilize already combined nitrogen in the soil, so conclusive seemed the experiments conducted by Boussingault and by Lawes, Gilbert, and Pugh at Rothamsted. But a fresh turn was given to the whole question by the discovery made by Hellriegel and Wilfarth in 1887 that the leguminous plants in virtue of the bacteria living symbiotically in the nodules on their roots were able to fix atmospheric nitrogen. From that time research has been directed towards the problem of utilizing and rendering more effective this particular *Bacterium radicicola*. Widely distributed as it is in the soil, it is yet not universally present; heaths and peaty soils, for example, that have never been under cultivation frequently lack it entirely; consequently, it is impossible to obtain a satisfactory growth of leguminous crops, upon which in many cases the possibility of successful reclamation is based, until this class of land has been inoculated with the appropriate organism.

Again, although but one species of bacterium seems to exist, yet several investigators have found that by its continued existence in symbiosis with particular host plants it has acquired a certain amount of racial adaptation, so that, for example, clover will flourish best and assimilate the most nitrogen if it be inoculated with the organism from a previous growth of clover, and not from a pea or a bean plant.

The conclusion naturally follows that it may be necessary to inoculate each leguminous crop with its appropriate organism in order to secure a maximum yield. The first practical efforts in this direction did not, however, meet with much success: the cultivations used for inoculation were weak, and, when sown with the seed, in many cases died before infection took place. Even when the formation of nodules followed, yet the assimilation of nitrogen was not great. The question in fact turns upon the degree of 'virulence' possessed by the subcultures used for inoculation. It is well known with other bacteria how their specific actions may be-

come entirely modified by growing on particular media, or at a high temperature, and even by long-continued growth under laboratory conditions.

B. radicicola does not develop very freely on the ordinary media used for the cultivation of bacteria, nor can it be made to fix much free nitrogen when removed from the host plant. In particular it is maintained that the medium used, gelatine with an infusion of some leguminous plant, causes the organism to lose, to a very large extent, its power of fixing nitrogen, because it contains so much combined nitrogen. G. T. Moore, for instance, says: "As a result of numerous trials, however, it has been found that although the bacteria increase most rapidly upon a medium rich in nitrogen, the resulting growth is usually of very much reduced virulence; and when put into the soil these organisms have lost the ability to break up into the minute forms necessary to penetrate the root-hairs. They likewise lose the power of fixing atmospheric nitrogen, which is a property of the nodule-forming bacteria under certain conditions." Latterly the subcultures have been made on media practically free from nitrogen, on agar agar, for example, or on purely inorganic media, supplied, of course, with the carbohydrate, by the combustion of which is to be derived the energy necessary to bring the nitrogen into combination.

In example of the two preparations now being distributed on a commercial scale, the one sent out by Professor Hiltner, of the Bavarian Agricultur-botanische Anstalt, consists of tubes of agar which have to be rubbed up in a nutrient solution containing glucose, a little peptone, and various salts, and this after growth has begun is distributed over the soil or the seeds just before sowing. Moore, of the U. S. Department of Agriculture, finding that the bacterium will resist drying, dips strands of cotton-wool into an active culture medium and then dries them. The cotton-wool is then introduced into a solution containing maltose, potassium phosphate and magnesium sulphate; in a day or two growth becomes active, and the solution is distributed over soil or seed.

It is too early yet to determine what measure of success has been attained by these inoculations with pure cultures; but in considering the results a sharp distinction must be drawn between their use on old cultivated and, such as we are dealing with in the United Kingdom, and under the conditions which prevail in new countries where the land is often being brought under leguminous crop for the first time. Few of our English fields have not carried a long succession of crops of clover, beans, vetches and kindred plants; the *Bacterium radicicola* is abundant in the soil; and, however new the leguminous plant that is introduced, infection takes place unfailingly, and nodules appear. It is true that the organism causing nodulation may not belong to the particular racial adaptation most suited to the host plant, and that in consequence an inoculation from a suitable pure culture might prove more effective. Again, it is possible that even a plant like clover, which would be infected at once through the previous growth of the crop, might be made a greater collector of nitrogen through the introduction of a race of bacteria which had acquired an increased virulence; but in either of these cases the most that could be expected from the inoculation would be a gain of 10 per cent. or so in the crop. This great, though limited, measure of success depends upon two things—on obtaining races of *B. radicicola* possessing greater virulence and greater nitrogen-fixing power than the normal race present in the soil, and again on the possibility of establishing this race upon the leguminous crop under ordinary

field conditions, when the introduced organisms are subject to the competition both of kindred bacteria and of the enormous bacterial flora of any soil. Up to the present all evidence of greater nodule-forming power and increased virulence of the artificial cultures has been derived from experiments made under laboratory conditions without the concurrence of the mass of soil organisms.

In the other case, however, where new land is being brought under cultivation and leguminous crops are being grown for the first time, there can be no doubt of the great value of inoculation with these pure cultures of the nitrogen-fixing organism. An example is afforded in Egypt, where land that is 'salted,' alkali or 'brak' soil, is being reclaimed by washing out the salt; inoculation may be necessary before a leguminous crop can be started on such new land, though in many cases the Nile water used for irrigation is quite capable of effecting inoculation. The body of evidence brought together by the United States Department of Agriculture is very convincing, and shows in repeated examples that the use of Moore's cultures has enabled farmers to obtain a growth of lucerne and kindred plants, which before had been impossible. In view of the economic importance the lucerne or alfalfa crop is assuming in all semiarid climates, the financial benefit to the farming community is likely to be great and immediate. And since in the development of South African farming the lucerne crop is likely to become very prominent, both as the most trustworthy of all the fodder crops and as the one which brings about the maximum enrichment of the soil by its growth, the behavior of the lucerne plant as regards bacterial infection in South African soils is worthy of most careful investigation. It is necessary to know to what extent nodules are formed when lucerne is planted on new soils in South Africa, as, for example, on freshly broken-up veldt; the condition of the organisms within the nodule should be investigated, so as to ascertain if improvement be possible by inoculation from pure cultures, either imported or prepared *de novo* from lucerne within the country. These and kindred questions connected with the symbiosis of the nitrogen-fixing organism and the leguminous plants must to a large extent be worked out afresh in each country, and South Africa, with its special conditions of soil and climate, can not take on trust the results arrived at in Europe or America.

I have spoken of the enrichment of the soil due to growing lucerne, caused by the decay of the great root residues containing nitrogen derived from the atmosphere; an enrichment which is quite independent of the amount of similarly combined nitrogen taken away in the successive crops of leafy growth. Some of the Rothamsted experiments show very clearly how great the gain may be. In the first place I will call your attention to the effect of a crop of red clover grown in rotation upon the crops which succeeded it, since in the Agdell rotation-field we get a comparison between plots growing red clover once every four years and other plots on which a bare fallow is substituted for the clover.

The table shows that in one particular case, when an extra large crop of clover was grown, notwithstanding the fact that the clover plots yielded between three and four tons per acre of clover hay, yet the wheat crop which followed this growth of clover was 15 per cent. better than the wheat crop following the bare fallow. The swede turnip crop, which followed the wheat, although similarly and heavily manured on both plots, continued to be better where the clover had been grown two years previously; and even the barley,

TABLE I.

Manuring for Swede Crop Only.	Clover, 1894.	Wheat, 1895.			Roots, 1896.			Barley, 1897.		
		After Fallow.	After Clover.	Increase Due to Clover.	After Fallow.	After Clover.	Increase Due to Clover.	After Fallow.	After Clover.	Increase Due to Clover.
	Cwt.	lb.	lb.	Per Cent	Cwt.	Cwt.	Per Cent.	lb.	lb.	Per Cent.
Mineral Manure...	59.7	4,220	5,180	+22.7	179.1	244.5	+36.5	2,103	3,991	+89.8
Complete Manure..	76.7	4,547	5,209	+14.6	379.8	388.8	+ 2.4	3,595	4,913	+36.7

which came next, three years after the clover, showed a decided superiority on the clover land. Thus a clover crop, itself wholly removed from the land, exercised a marked influence for good on at least the three succeeding crops grown under the ordinary conditions of farming. Next we can make a comparison between red clover and lucerne. On some of the Rothamsted plots various leguminous plants have been grown for many years, with indifferent success indeed, because of the well-known reluctance of the land to support such crops except at intervals of four or more years. Eventually the plots on which these indifferent crops had been secured were ploughed up and sown with wheat without any manure. In five years the wheat was thus grown on the residues left in the soil by the previous leguminous crops, and from the table will be seen the comparative value of these residues in the case of lucerne and red clover.

TABLE II.

Harvest.	Grain.		Total Produce.	
	After Lucerne.	After Red Clover.	After Lucerne.	After Red Clover.
	Bushels.	Bushels.	Pounds.	Pounds.
1899	39.3	43.0	8,108	8,505
1900	28.9	19.1	4,554	2,992
1901	27.0	21.4	4,054	3,185
1902	20.1	17.7	3,553	3,023
1903	19.9	16.7	3,035	2,528
Total.	135.2	117.9	23,304	20,223

As we have previously seen how great the benefit of a single year's growth of red clover may be on the succeeding crops, an idea can be formed from the comparison in the latter table of how much more lucerne may contribute towards building up a fertile soil; a point which was very markedly brought out in the experiments of the late Mr. James Mason.

The question of the fixation of atmospheric nitrogen by bacterial agencies does not, however, end with the organisms living symbiotically on the leguminous plants, for several other organisms have latterly been discovered which possess the power of fixing nitrogen independently, provided they are supplied with the necessary nutriment. Of late attention has been chiefly directed to a conspicuous organism known as *Azotobacter chroococcum,* which may be readily identified in most cultivated soils. The impure cultures (which may be quickly obtained by introducing a trace of soil into a medium containing no nitrogen, but a little phosphate and other nutrient salts, together with one or two per cent. of mannite or other carbohydrate) fix nitrogen with considerable activity; in one case, for example, when working with a Rothamsted soil, as much as 19 mg. of nitrogen were fixed for each gram of mannite employed and partially oxidized. But Beyerinck, the discoverer of the organism, now attributes the nitrogen fixation to certain other organisms which live practically in symbiosis with the *Azotobacter,* and which are present in the impure cultures just referred to. The exact source of the nitrogen fixation may be left a little doubtful; still the main fact remains that from the bacteria present in many soils one or a group may be found capable of effecting

rapid and considerable nitrogen fixation if the necessary conditions, chiefly those of carbohydrate supply, are satisfied.

But how is the carbohydrate supply to be obtained? Under the normal conditions of arable land farming there are few possibilities in this direction, the occasional ploughing under of a green crop being the only considerable addition of organic matter other than manure, which is possible in practise. As a matter of experience the plots at Rothamsted, which have been growing crops without manure continuously for the last fifty years, indicate but little gain of nitrogen from the atmosphere. After a rapid fall in production for the first few years, the yield has become so nearly stationary that any further decline is not as yet discernible amid the fluctuations due to season.

Table III. shows the average yield during the last five decades of dry matter and of nitrogen from four of the unmanured plots at Rothamsted; it will be seen that the difference in the production during the last as compared with the second period of ten years is no more than would be covered by seasonal variations. In other words, the yield, which, as we learn in other ways, is mainly determined by the amount of available nitrogen, has reached a state of equilibrium when the resources of the soil, the material brought down by the rain, and the nitrogen-fixing agencies taken together are just equal to providing the crop with about 17 lbs. of nitrogen per acre per annum in addition to the unknown amounts removed by drainage and in the weeds. The small amount of fixation this indicates and the corresponding low level of production must be set down to the lack of combustible carbohydrate, due to the very complete removal of the various crops from the soil, since the root and stubble left behind after the growth of a cereal crop amount to but a small fraction of the total produce.

In the case of grass-land the conditions are entirely different, especially when we are dealing with wild prairie or forest, where the annual growth of carbohydrate falls back to the soil and is available for such organisms as the *Azotobacter*. At Rothamsted two plots of land which were under arable cultivation twenty-five years ago have been allowed to run wild and acquire a natural vegetation of grasses and weeds, subject to no disturbance beyond the occasional eradication of scrub and bushes. Samples of the soil taken when the land was still under the plough have been preserved, and the comparison of these with new samples drawn during the last year shows enormous accumulations of nitrogen, even when every allowance has been made for certain inevitable errors in

TABLE III.

Average Amounts of Dry Matter and Nitrogen in Total Produce of Various Crops, grown without Manure at Rothamsted.

	Dry Matter.						Nitrogen.
	Averages Over.					Whole Period.	Whole Period.
	10 Years, 1852-1861.	10 Years, 1862-1871.	10 Years, 1872-1881.	10 Years, 1882-1891.	10 Years, 1892-1901.		
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
Broadbalk Wheat.	2,199	1,791	1,346	1,480	1,514	1,666	17.0
Hoos Barley........	2,352	1,797	1,303	1,229	1,120	1,560	15.3
Agdell Rotation[2]..	2,331	1,817	1,403	1,644	1,295	1,696	17.6
Park Hay[3]........		2,082	2,144	2,196	1,421	1,961	33.8

[2] Carted fallow portion.

[3] First and second crops.

sampling the soil (see Table IV.). Of these two fields the Geescroft plots are the more interesting, for though showing the gain of nitrogen is less (45 lbs. per acre per annum against 98 lbs. on Broadbalk), yet continued observation of the herbage that has sprung upon this field has shown the absence of any leguminous plants. According to a botanical analysis made in 1903 the leguminous plants only constituted 0.4 per cent. of the vegetation (as weighed in the dry state) on the Geescroft 'wilderness,' whereas the corresponding plot on Broadbalk contained 25 per cent. Now, with no leguminous plants to act as collectors of nitrogen the considerable gains of combined nitrogen on this Geescroft land must be set down to the work of *Azotobacter* or kindred organisms which get their necessary supply of carbohydrate from the annual fall of the grassy vegetation.

TABLE IV.

Accumulation of Carbon and Nitrogen in Soil of Land allowed to run wild for more than Twenty Years.

		Per Cent. in Dry Soil.			
		Carbon.		Nitrogen	
		1881-3[4]	1904	1881-3[4]	1904
Broadbalk	1st 9 inches.	1.143	1.233	0.1082	0.1450
	2d "	0.624	0.703	0.0701	0.0955
	3d "	0.461	0.551	0.0581	0.0839
Geescroft	1st 9 inches.	1.111	1.494	0.1081	0.1310
	2d "	0.600	0.627	0.0739	0.0829
	3d "	0.447	0.435	0.0597	0.0652

	Broadbalk.		Geescroft.	
	1881	1904	1883	1904
Nitrogen – lbs. per acre..	5,910	8,110	6,043	6,978
Nitrogen—Increase per acre, per annum, lbs..	—	97.8	—	44.5
Ratio of Carbon to Nitrogen....................	9.4	7.7	8.9	9.2
Ratio of Carbon to Nitrogen in Increase......	—	2.9	—	10.7

The fixation of nitrogen must be an oxidizing process, for no other natural reaction is likely to provide the energy necessary to bring the nitrogen into combination. This being so, some light is thrown on the process in nature by an examination of the ratio of carbon to nitrogen in the accumulations referred to above. At starting, the ratio of carbon to nitrogen in the organic matter of the two soils was much the same—a little less than 10 to 1—but the increase of carbon and nitrogen in the Broadbalk field, *i. e.*, the organic matter which has accumulated in the interim, shows a ratio of only 3 to 1, while the corresponding accumulations in Geescroft field show a ratio not far removed from the original of about 11 to 1. In other words, where there has been the greater accumulation of nitrogen on the Broadbalk field, there has been the greater combustion of carbohydrate, so that the accumulation of carbon is actually as well as relatively smaller. Bacteriological tests seem to show a much greater development of *Azotobacter* with increased powers of fixation in the soil from the Broadbalk than from the Geescroft wilderness; a fact to be correlated with the presence of a fair proportion of carbonate of lime in Broadbalk, but not in Geescroft field.

Another example may be drawn from the experiments carried on by the late Mr. James Mason at Eynsham Hall, Oxon. He had large cemented tanks filled with burnt clay mixed with appropriate quantities of calcium carbonate and phosphate and other nutrient salts, but containing no nitrogen. One of these tanks, after inoculation with a trace of ordinary soil, was sown with a mixture of grass-seeds and has carried a weak but purely grassy vegetation ever since. According to a recent analysis the soil of this tank has in fifteen years accumulated 0.029 per cent. of nitrogen in the surface soil and 0.117 per cent. in the second layer—equivalent to about 870 and 350 lbs. per acre per annum,

[4] Broadbalk, 1881; Geescroft, 1883.

the ratio of carbon to nitrogen in the accumulation being about 18 to 1 and 12 to 1, respectively.

Henry has also shown that the shed leaves of many forest trees during their decay may bring about the fixation of nitrogen; and this fact, which again depends on the oxidation of the carbohydrates of the leaf to supply the necessary energy, has been confirmed in the Rothamsted Laboratory, as well as the presence of *Azotobacter* on the decaying leaf.

It is obvious that one of the most interesting fields for the study of these organisms must lie in the virgin lands of a country like South Africa. We all know that virgin soil may, on the one hand, represent land of almost perpetual fertility; on the other, it may constitute wastes of any degree of sterility. What are the conditions under which ensues that accumulation of humus whose nitrogen will become available under cultivation, the 'black soils' famous in every continent? The ecological botanists are working out some of the great climatic conditions, the amount and distribution of rainfall and temperature which are associated with 'steppe' areas of great accumulated fertility, but the bacterial flora which is fundamentally bound up with the problem remains as yet unexplored.

It is possible also that on some of the newer lands this and kindred bacteria are absent because the conditions are not entirely suitable to their development. A. Koch has shown that the presence of calcium carbonate is necessary to the action of *Azotobacter*, and determinations of the power of soils from the various Rothamsted fields to induce fixation confirm his results, the development of the organism in question being feeble when the soil was derived from some of the fields that had escaped the 'chalking' process to which the calcium carbonate of the Rothamsted soils is due.

The value of calcium carbonate in this connection only adds to the many actions which are brought about by the presence of lime in the soil—lime, that is, in the form of calcium carbonate, which will behave as a base towards the acids produced by bacterial activity. The experimental fields at Rothamsted afford a singular opportunity of studying the action of lime, since the soil, a stiff, flinty loam, almost a clay, is naturally devoid of calcium carbonate, though most of the cultivated fields contain now from 2 to 5 per cent. in the surface soil, due to the repeated applications of chalk, which used to be so integral a part of farming practise up to the middle of the nineteenth century. Where this chalking process has been omitted, as is the case in one or two fields, the whole agricultural character of the field is changed: the soil works so heavily that it is difficult to keep the land under the plough; and as grass land it carries a very different and altogether inferior class of vegetation. On the experimental fields it has been possible to measure the rate at which natural agencies, chiefly the carbonic acid and water in the soil, are removing the calcium carbonate that has been introduced into the surface soil, and it is found to be disappearing from the unmanured plots under arable cultivation at an approximate rate of 1,000 lbs. per acre per annum; a rate which is increased by the use of manures like sulphate of ammonia, but diminished by the use of nitrate of soda and of dung. Failing the renewal of the custom of chalking or liming—and its disuse is now very general—the continuous removal of calcium carbonate thus indicated must eventually result in the deterioration of the land to the level of that which has never been chalked at all, and even a state of sterility will ensue if much

use is made of acid artificial manures. That many soils containing naturally only a trace of calcium carbonate remain fairly fertile under ordinary farming conditions is due, on the one hand, to an action of the plant itself, which restores to the soil a large proportion of the bases of the neutral salts upon which it feeds, and partly to the action of certain bacteria in the soil, which ferment organic salts like calcium oxalate existing in plant residues down to the state of carbonate. Were it not for these two agencies restoring bases the soil must naturally lose its neutral reaction, since the process of nitrification is continuously withdrawing some base to combine with the nitric and nitrous acids it sets free.

This varying distribution of calcium carbonate in soils suggests another section of my subject, in which great activity has prevailed of late—the undertaking of a systematic series of soil analyses in any district, with a view to making soil maps that shall be of service to the agriculturist. The Prussian government has long been executing such a soil survey, and during the last few years a similar project has been pushed forward with great energy in the United States; in France and in Belgium several surveys are in progress, but in the United Kingdom the matter has so far only excited one or two local attempts. While the basis of such work must always be the geological survey of the district, a geological survey in which, however, the thin 'drift' formations are of greater importance than the solid geology, there are certain other items of information required by the farmer which would have to be supplied by the agricultural specialist. In the first place, the farmer wants to be told the thickness of the superficial deposits; he requires frequent 'ground profiles,' so that he can construct an imaginary section through the upper 10 feet or so of his ground. To take a concrete example: the chalk in the south of England is very often overlaid by deposits of loam, approaching the nature of brick earth, and the agricultural character of the land, its suitability for some of the special crops, like hops and fruit, which characterize that district, will be wholly different according as the deposit is 3 feet or 10 feet deep. The proximity and, if near the surface, the direction of flow of the ground water are also matters on which there could be given to the farmer information of great importance when questions of drainage or water-supply have to be considered. It is necessary also to refine upon the rough classification of the soil and subsoil which alone is possible to the field surveyor, one of whose functions will be to procure typical samples of which the texture and physical structure can afterwards be worked out in the laboratory. Geological formations are constantly showing lithological changes as one passes along their outcrop either in a vertical sense or in their lateral extension; and these changes are often reflected by corresponding changes in the character of the soil which are of commercial importance.

But while the mechanical analysis of the soil has been of late the basis upon which all soil surveys are constructed, it is of equal importance, at any rate in the older countries under intensive cultivation, to undertake certain chemical determinations, which come to possess a new value when taken in connection with a soil survey. It has been generally demonstrated that an analysis, physical and chemical alike, of the soil of a particular field, taken by itself, possesses but little value. The physical analysis will indicate roughly the character of the soil, but very little better than could have been learned by walking over the soil and digging in it for five minutes; the chemical analysis will disclose any glaring deficiencies; but, as a rule, the analytical

figures will be of a very indecisive character, and will lead to little information of practical value. This is because the productivity of a given piece of land depends upon a large number of agencies, any one of which may be the limiting factor in the crop yield. We may enumerate, for example, temperature and water-supply, both determined by the climate, by the natural physical structure of the soil and by the modifications in its texture induced by cultivation; there are further the aeration and the actual texture of the soil, the initial supply of plant-food of various kinds and, again, the rate at which this last item is rendered available to the plant by bacterial action or by purely physical agencies. All these factors interact upon one another. To all of them and not merely to the nutrient constituents does Liebig's law of the minimum apply; so that any one may become the limiting factor and alone determine the yield. It is of no use, for example, to increase the phosphoric-acid content of a soil, however deficient it may be, if the maximum crop is being grown that is consistent with the water-supply, or if the growth of the plant is being limited by insufficient root range caused by bad texture and the lack of aeration in the soil. However much we may refine our methods of analysis, we may take it as certain that we shall never be able to deduce *à priori* the productivity of the soil from a consideration of the data supplied by the analysis. The function, then, of soil analysis is not to make absolute deductions from the results, but by a comparison of the unknown soil under examination with other soils already known to interpret the divergences and similarities in the light of previous experience. That a given soil contains one tenth per cent. of phosphoric acid or one fiftieth per cent. of the same constituent soluble in a dilute citric-acid solution is in itself meaningless information; but it becomes of great value when we know that the normal soils of that particular type contain less than this proportion of phosphoric acid as a rule, and yet show no particular response to phosphatic manuring.

What, then, the soil analyst can do is to characterize the type, ascertain its normal structure and composition, and correlate its behavior under cultivation, its suitability for particular crops and its response to manuring in various directions. Thus an unknown soil may by analysis be allotted to its known type, deviations from the type can be recognized and conclusions may be drawn as to the connection of these defects.

Valuable as recent development of soil analysis may have been (and I allude in particular to the improvements in the methods of mechanical analysis which have been worked out in the United States Department of Agriculture, to the many investigations that have been made on the measurement of 'available' plant-food by attack with weak acid solvents, to the determinations of the bacterial activity of the soil), the results they yield can only be truly interpreted when they can be compared with a mass of data accumulated by the use of the same methods on known soils.

One of the services, then, which the farmers in every country may very properly expect from the scientific man is such a survey of the principal soil types, affording the necessary datum lines by which the comparative richness and poverty of any particular soil may be gauged. In an old settled country like the United Kingdom such a survey would guide the farmer in his selection of manures; in a new country the advantages would be even more apparent, as the areas appropriate to particular crops would be indicated, and settlers would be saved from many expensive attempts to introduce things for which their land was unsuited.

It would also be possible to indicate the

measures which should be taken to ameliorate the nature of the poorer soils, for, remote as may now seem the prospects of spending time and labor on bad land in new countries where there is still a choice of good, once the road to improvement is indicated little by little the work will be done. It is hardly realized to what extent the soils in England have been 'made'; the practise of 'chalking,' previously mentioned as having doubled or trebled the value of the Rothamsted land, must have added between 100 tons and 200 tons of chalk per acre to those soils before the end of the eighteenth century, and in other parts of the country marling, claying, incorporation of burnt earth and other lighter material have contributed enormously to render the present degree of fertility possible.

The main facts of the nutrition of the plant have been so long established that it is not always realized how much still remains unknown. It has become a commonplace of the text-books that the plant needs nitrogen, phosphoric acid, potash, often in excess of the quantities present in a normal soil; so that these substances alone are considered of manurial value, other necessary materials like lime, magnesia, iron, sulphuric acid and chlorine being practically never lacking under natural conditions. But the function of these substances in the development of particular plants, the manner in which the character of the crop is affected by an excess or a deficit, is still imperfectly apprehended. We realize the dependence of vegetative development upon the supply of nitrogen, and how an excess defers maturity; we are also beginning to gather facts as to the manner in which an overplus of nitrogen causes alterations in the structure of the tissues and variations in composition of the cell contents that result in increased susceptibility to fungoid attack. Again, it is clear that potash takes a fundamental part in the process of assimilation, the production of carbohydrate in all forms being dependent on the supply of potash; but of the manner or the location of the action we have no knowledge. Our ignorance of the function of phosphoric acid is even greater; broadly speaking, it hastens maturity, and is bound up with such final processes in the plant's development as the elaboration of seed. With this we naturally correlate on *à priori* grounds the presence of phosphorus in the nucleo-proteids; but there is no particular evidence that excess of phosphoric acid leads to increased assimilation of nitrogen.

Some of the barley plots at Rothamsted show this very clearly; where there has been no phosphatic, but a nitrogenous, manuring for the last fifty years, the amount of nitrogen assimilated by the crop is diminished, but the gross production of dry matter is still further diminished. By the addition of phosphoric acid the gross production is increased to a greater degree than the amount of proteid formed is increased, so that the crop shows now a smaller percentage of nitrogen and a lower ratio of nitrogen to phosphoric acid than on the plots which are experiencing phosphoric-acid starvation. In other words, where an excess of nitrogen is available the amount assimilated does not increase *pari passu* with the amount of phosphoric acid which the plant can obtain.

But with these three substances all exact knowledge ceases; magnesia, sulphuric acid and chlorine are invariable and necessary constituents of all plants, yet their function and their practical effects are still unknown. To take a further example, it was early in the history of agricultural science that silica was discovered to be the chief constituent of the ash of cereals and of a few other plants. Liebig's term of 'silica plants' still survives to show the importance once attached to this body, and

the earlier experimenters with manures used soluble silicates with the idea of thereby increasing the stiffness of straw. But further investigations showed that cereals could be brought to maturity without any supply of silica, and that the stiffness of the straw was a physiological matter in no way conditioned by silica. As a consequence this plant constituent has now been disregarded for a long time. But it is idle to suppose that a substance present, for example, to the extent of 60 per cent. or so in the ash of the straw of wheat, has no part to play in the nutrition of the plant. Among the Rothamsted experiments there are fortunately some barley plots which have received soluble silica for many years, and a recent examination of the material grown on these plots begins to cast some light on the function of silica. Its effect upon the plant is in some way parallel to that of phosphoric acid; on the plots which have had no phosphatic manure for more than fifty years an addition of soluble silica increases the crop, increases the proportion of grain and hastens the maturity in exactly the same fashion, though to a less degree, than an addition of phosphoric acid. The results point to the plant rather than the soil as being the seat of the action; a plant that is being starved of phosphoric acid can economize and make more use of its restricted portion if a quantity of soluble silica be available. There is no possibility of replacing phosphoric acid by silica in the general nutrition of the plant, but the abundance of silica at the disposal of the cereals certainly enables them to diminish their call for phosphoric acid from the soil.

Much in the same direction lie the researches which are being pursued with so much vigor by Loew and his pupils in Japan on the stimulus to assimilation and plant development which is brought about by infinitesimal traces of many metallic salts not usually recognized as being present in plants at all. It has been often recognized that substances which are toxic to the cell in ordinary dilutions may, when the dilution is pushed to an extreme, reach a point at which their action is reversed and begins to stimulate. Probably some of the materials used as fungicides and inhibitors of disease act in this fashion by strengthening the whole constitution of the plant rather than by directly destroying or checking the growth of the fungus mycelium. The subject is certainly one which promises to yield results of value in practise, and calls for more extended and exact observation.

The importance of research on the particular function of the various constituents of the crop lies in the fact that it is only by the possession of such knowledge we may possibly influence in desired directions the quality of our crops. With the effect of manuring upon the yield of most of our crops we are now familiar, but the question of 'quality,' almost as important as that of yield, forms a more difficult problem. One particular example may be cited, that of wheat, because of late years it has been a subject of investigation in most wheat-producing countries. That quality of wheat which is of special commercial importance is its so-called 'strength,' the capacity of yielding flour of such a consistency in the state of dough as will retain the gases produced in fermentation with the formation of a tall, well-piled loaf. This property of 'strength' is usually found in a hard horny and translucent grain, the soft, mealy-looking wheats being as a rule 'weak.' Again, the strong wheats usually originate from districts like the Hungarian plain, the Northwest of America, and south Russia, countries characterized by a typical continental climate, cold and dry in the winter, with rains in the late spring and early summer, and a gradually increasing dry-

ness and temperature up to the time of harvest. The wheats grown under the opposite conditions of a winter rainfall and a dry summer, as on the Pacific slope of North America, or an evenly distributed rainfall as in England or France, are on the whole weak. The differences in this quality are considerable when measured commercially; for example, in most seasons the best Manitoban wheat will be worth 20 to 25 per cent. more than a corresponding grade of English wheat on the London market. The source of strength lies among the nitrogenous constituents of the wheat flour; it can be measured roughly either by determining the proportion of nitrogen in the flour, or by the old process of washing away the starch and leaving the gluten. Neither process agrees exactly with baking tests, nor do any of the more recent attemps to differentiate the wheat proteids by their solubility in various media, as, for example, the determination of the so-called *gliadin glutenin ratio*. In fact, in the present state of our knowledge of the possibilities of identifying and separating the proteids in a pure state, there is little likelihood of being able to make out the subtle differences of chemical composition which result in the varying quality of the wheat proteid mass. For example, the relative strength of different varieties of wheat grown under similar conditions will follow the order in which the wheats are placed by their content in nitrogen; yet if, as at Rothamsted, an increased nitrogen content in the wheat is brought about by excessive nitrogenous manuring, the product is actually considerably weaker than wheat on the other plots grown under more normal conditions. The manuring, while increasing the nitrogenous matter of the wheat, has probably introduced a new factor in the shape of a more prolonged development resulting in the lack of those final changes in the nature of the wheat proteids which make for strength. This seems to be indicated by the fact that on storage this particular abnormal wheat gradually increases in strength up to the normal, though never to the degree that would be indicated by its nitrogen content. But though the chemical methods of estimating the strength of wheat have as yet proved inconclusive, some idea of the factors determining this quality has been reached from practical baking tests combined with measurements of the gluten and nitrogen content of the flour. In the first place manuring proves a very small factor; the composition of the grain of wheat is extraordinarily stable and the plant reacts to diversities in nutrition by producing more or less grain rather than by altering its composition. Even under the exceptionally pronounced variations in the manurial conditions of the Rothamsted plots, the composition of the grain fluctuates more with changing seasons than with changed manuring. Within the limits of healthy growth and ripening the date of sowing the wheat has no effect upon the quality of the grain; the same wheat sown at monthly intervals from October to March gave practically identical quality in the grain, and a number of comparisons between autumn and spring sowing led to no definite conclusion. Soil has also a comparatively small effect, though, of course, different soils, by inducing differences in the supply of water to the plants and in the temperature, practically result in differences of climate. The effect of climate is large, whether tested by growing the same variety in different countries or by inducing artificial variations in the climate of wheats grown under experimental conditions. But while the climatic factor proves to be large it is less than was anticipated; an English soft wheat, for example, grown on the Hungarian plain for two seasons, has not altered greatly in character nor taken on the characteristic ap-

pearances of the wheat of the district. A specially strong wheat from the Canadian Northwest, after some considerable fall of strength in the first English crop, has fallen no further after three successive crops, and still retains all the characters of an exceptionally strong wheat, although the yield remains poor from an English standpoint. Other varieties have rapidly and entirely lost their strength when changed to English conditions from America, or Hungary, or Russia; many, however, while showing the effect of climate, yet stand apart from the typical English wheats and show no tendency to 'acclimatize' in the sense of acquiring the character of the local varieties. In the whole work the thing which stands up most prominently is the fundamental importance of the 'variety'; each race, each botanical unit as it were, possesses an individuality and yields grain of a characteristic composition; and though climate, soil, season, manuring, are factors producing variation in the composition, they are all small compared with the intrinsic nature of the variety itself. Similar conclusions follow from the work of Wood and his colleagues upon the composition of mangels, and of Collins on the composition of swedes. The proportion of dry matter and sugar in the root, while varying markedly in the individual roots, possesses a typical value for each race; and though season, locality and to some extent manuring affect the composition, the changes thus induced are not great.

Starting, then, from this point, that variety or race is the chief factor in the composition of a given plant, and that, once the variety is fixed, the other factors, which are more or less under control, such as manuring, soil and climate, have but minor effects upon the quality, the road to the improvement of the quality of our farm crops lies in the creation of new varieties by breeding. An improved variety is all clear gain to the farmer; climate, season and to a large extent soil are outside his control; while better manuring and cultivation, however much their cost may be lessened by increased skill, yet involve expenditure and become unremunerative above a certain point. But an improved variety, without costing any more to grow, may increase the returns by 10 or 20 per cent., in some cases may nearly double them.

As regards the value of selection, Wood shows that the composition of the mangel, which has been selected solely for such external qualities as shape and habit, has remained stationary during the fifty years or so for which we possess any information; while between 1860 and 1890 the sugar beet has had its sugar content raised from an average of 10.9 to 15 per cent. by the steady selection of seed-mothers for their richness. The prospects of breeding new varieties of wheat, and particuarly of securing improvements in such qualities as 'strength,' have been enormously improved within the last year or two through the investigations which have followed on the rediscovery of Mendel's law of inheritance. Wheat as a normally self-fertilized plant is particularly suited to the investigation of Mendel's law, and the work of Biffen shows that, with a few possible exceptions, the characters of the parent varieties are inherited strictly in accordance with the expectations derived from a consideration of that law. The great practical importance of this generalization lies in the fact that it thus becomes possible to pick out with certainty fixed types in the third generation of the hybrids, whereas without the guidance of Mendel's law and working by the old plan of selection, followed by continuous 'rogueing,' it was impossible ever to secure a pure strain unless by chance an individual possessing

pure recessive or pure dominant characters had been hit upon from the first.

Biffen's work further indicates that the power of producing a glutinous grain, such as will lead to 'strength' in the flour, is a Mendelian character, following the same laws of inheritance as the bearded or beardless habit or the color of the grain or chaff. Extreme strength shown in any particular wheat can then be picked out and combined with any other essential qualities, such as the yield and the character of the straw, which distinguish our present varieties of wheat. Of course the inheritance of a quality like strength, which is only relative between different varieties, can not be traced with the sharpness with which such characters as the long-awned bearded type can be followed; still the variation that is, as it were, superimposed upon the 'strength' or 'weakness' representing the inherited Mendelian character is not sufficient to obliterate the evidence of inheritance according to the law. And, of course this variation of individual seedlings in the 'strong' section above and below the degree of strength possessed by the parent, *i. e.*, the inherited character, gives the plant-breeder his opportunity of improving such a quality at the same time as he is combining with it the other characteristics that are desired in the new varieties. Biffen's work among the wheat hybrids touches also upon another point of special importance to South African farming, where the incidence of 'rust' forms the greatest obstacle of extensive and successful wheat-growing. The climatological conditions which make for a rust attack have not been worked out, as far as can be judged from the behavior of English wheats in various seasons, together with the prevailing climates in countries where rust is specially prevalent; a flush of growth in the spring followed by high temperatures will favor the disease, but South Africa, with its great variations in the amount and incidence of the rainfall and with its very different temperatures, affords a very good opportunity for obtaining information on this point. Returning, however, to the question of variety, it is generally recognized that relative immunity or susceptibility to an attack of yellow rust is characteristic of particular varieties, and Biffen finds that such 'immunity' is a true Mendelian character, recessive and therefore only appearing in the second generation of hybrids between a rusting and rust-proof parent. It is not correlated with shape or character of the leaf, but is transmitted from one generation to another quite independently, and can, therefore, be picked out of a desirable parent and combined with other qualities of value in different parents. Here, again, we are dealing with a character that is only relative, for no wheat can be called either absolutely rust-proof or entirely susceptible; the offspring that have inherited immunity will still vary a trifle among themselves in the degree of their resistance to attack, and in this possibility of variation lies the chance of the plant-breeder to improve upon the rust-resisting powers of the varieties we now possess.

The whole work of the plant-breeder is of singular importance in a country like South Africa whose agricultural history is so recent. Our European crops represent the culminating points of a tradition, and are the fruit of the observation and judgment of many generations of practical men working, as a rule, with chance material. The products are eminently suited to European conditions, but, as has been seen so often, they fail comparatively when brought into other climates and soils. It follows, then, that in a new country the work of the acclimatizer is one of the necessary foundations for agriculture, and this involves a careful study of climatology

and of the influence that the distribution of rainfall and temperature in various parts of the country has on the character of the crop.

Then the cross-breeder's work begins: acclimatization alone is hardly likely to yield the ideal plant, but by it are found plants possessing the features, one here and one there, that are desiderated; and starting with this ground material the hybridizer can eventually turn out an individual possessing to a large measure all the qualities that are sought for.

There is little hope that science can do anything wholly new for agriculture; acclimatization, breeding and selection have been the mainstay of farming progress since the beginning of time, just as the action of the nitrifying bacteria and of nitrogen fixation by the leguminous plants was instinctively apprehended by the earliest farmers of whom we have any record.

But with increasing knowledge comes more power, and particularly the possibility of accelerating the rate of progress; agricultural improvements in the past have resulted from the gradual and unorganized accretions of the observation and experience of many men, often of many generations, now that we are provided by science with guiding hypotheses and by the organization of experiment with the means of replacing casual opinions by exact knowledge. Even the properties of the soil and the character of our farm crops and animals—stubborn facts as they are and deeply grounded in the nature of things—ought to become increasingly plastic in our hands.

A. D. Hall.

SCIENTIFIC BOOKS.

Physiological Economy in Nutrition. By Russell H. Chittenden, Ph.D., LL.D., Sc.D. New York, F. A. Stokes Co. 1904.

This notable volume, the production of Professor Chittenden and his coworkers, of whom Professor Lafayette B. Mendel is the most prominent, finally dispels the tradition that a continued liberal allowance of proteid in a normal diet is a prerequisite for the maintenance of bodily vigor.

Professor Chittenden had suffered from persistent rheumatism of the knee joint and determined on a course of dieting which should largely reduce the proteid and calorific intake. The rheumatism disappeared and minor troubles such as 'sick-headaches' and bilious attacks no longer recurred periodically as before.

> There was a greater appreciation of such food as was eaten: a keener appetite, and more acute taste seemed to be developed and a more thorough liking for simple foods.

During the first eight months of the dieting there was a loss of body weight equal to eight kilograms. Thereafter for nine months the body weight remained stationary.

> Two months of the time were spent at an inland fishing resort, and during a part of this time a guide was dispensed with and the boat rowed by the writer frequently six to ten miles in a forenoon, sometimes against head winds (without breakfast) and with much greater freedom from fatigue and muscular soreness than in previous years on a fuller dietary.

During this latter period of nine months the nitrogen of the urine was determined daily. The average was 5.69 grams. During the last two months this was reduced to 5.40 grams. Experiments showed that about one gram of nitrogen was eliminated in the fæces, and that nitrogen equilibrium could be maintained with dietaries of low calorific value (1,613 and 1,549 calories) containing 6.40 and 5.86 grams of nitrogen. These figures correspond to diets containing 40 and 36.6 grams of proteid instead of 118 grams commended by Voit and honored by habit and tradition. The foods with the strongest flavors are meats.

Professor Chittenden believes that the large quantity of proteid in the ordinary diet is due to self-indulgence. He protests against such indulgence and believes that a futile strain is thereby placed upon the liver, kidneys and other organs concerned in the transformation and elimination of the end products of proteid metabolism.

These experiments, however, were not confined to an individual or even to a single group of individuals. Similar experiments were made on other professional men, on student athletes in training, and on soldiers under military regimen. The nitrogen in the urine was determined daily in twenty-six individuals for periods extending from five to nine months.

Summarizing the results obtained in all these groups of individuals, it is established that a diet containing about fifty grams of proteid (8 grams of nitrogen) is able to maintain the adult body machine in perfect repair. The professional group alleged a greater keenness for its work, the athletic group won championships in games, and the soldiers maintained perfect health and strength, many professing repugnance to meat when allowed it after five months of practical abstinence.

Although it is possible that the alleged improved mental condition may have been due to mental suggestion, still the fact remains that it has been absolutely proven by Chittenden's work that the allowance of proteid necessary for continued health and strength may be reduced for many months to one half or less what the habit of appetite suggests.

The reviewer would, however, remark that it still remains to be proven that the fifty grams of proteid in the diet—which is not greater than the body would metabolize in starvation—is advisable as a program for the whole of one's adult life. It may also be that more than this quantity is indicated, during convalescence from wasting disease, or during the muscular hypertrophy which accompanies preliminary training for muscular effort.

The reviewer believes that Professor Chittenden has fallen into error in the commendation of 2,500 to 2,600 calories as an ample energy content for the diet of a soldier at drill. Accurate information on this point is only obtainable through respiration experiments. Chittenden, pursuing a sedentary life, prescribes 2,000 calories for himself or 35 calories per kilogram of body weight, while Mendel requires 2,448 calories or 35.3 calories per kilogram. These are entirely normal values for people at light work. In the earliest calculations of Voit in 1866 it was shown that a man of 70 kilograms on a medium mixed diet produced 2,400 calories, or 34.3 calories per kilogram. Rubner allows 2,445 calories to men of 70 kilograms weight engaged in occupations involving light muscular work, men such as writers, draughtsmen, tailors, physicians, etc.

But the soldiers under Chittenden exercised for two hours in the gymnasium, then apparently drilled for one hour, and walked for another hour. This physical work can only be accomplished at the expense of increased metabolism. Zuntz has shown that to walk 2.7 miles in one hour along a level road requires an extra metabolism equivalent to the liberation of 159.2 calories in a well-trained man weighing 70 kilograms. If a soldier during four hours of exercise actually accomplished the equivalent of work of a walk of ten miles over and above what Professor Mendel accomplished in his laboratory, then the metabolism of the soldier would be larger than Professor Mendel's by 637 calories (159.2×4) or he would have had a total metabolism of 3,085 calories ($2{,}448 + 637$). This does not seem an improbable amount.

For ordinary laborers working eight to ten hours a day, such as mechanics, porters, joiners, soldiers in garrison and farmers, 3,000 calories, as advocated by Voit, is apparently not too great. Rubner's diet for the same class calls for 2,868 calories. Chittenden's allowance of 2,500–2,600 seems to the writer too small, while Atwater's of 3,400 appears excessive.

Unstinted praise for painstaking endeavor and unremitting toil belongs to the workers who have achieved this volume. It is a monument of fidelity and an inspiration to thoroughness in scientific work.

Graham Lusk.
University and Bellevue Hospital
Medical College.

The Insulation of Electric Machines. Turner and Hobart. Pp. vi + 297. 146 illustrations. New York, The Macmillan Company. 1905. Price, $4.50.

It is a difficult and tedious task to write a

book upon a subject which is in the empirical stage of its history, yet in this volume the authors have succeeded in producing a work which is rich in useful information, and which the electric constructor will find a valuable addition to his library. From a scientific standpoint perhaps the most interesting portion of the book is the second chapter, which summarizes very effectively the present state of knowledge regarding the dielectric strength of various materials under various conditions. Nothing is more convincing evidence of the need of further investigating the passage of electricity through gases than the discordant values obtained by different experimenters for the dielectric strength of air.

The constructor will find the chapters on field and on armature insulation and on the 'space factor' exceedingly practical and suggestive, and indeed wherever the authors have had the opportunity of drawing upon their own valuable experience and exercising untrammeled their nice discrimination the results are very satisfactory. Unhappily, insulation at present must rank as crude art rather than as science, and art, too, somewhat luridly colored by commercial daubers.

Of patented insulating preparations and secret compounds the name is legion, and good, bad and indifferent, all alike make the most extravagant claims, and back them up by experiments. These compounds can not be left without mention in a book on insulation, for some of them are highly meritorious, but proper and adequate treatment of them is a practical impossibility. In dealing with this part of their subject therefore, the authors can hardly do more than supplement the alleged facts by such data as are available and to let the matter go at that. They have at least avoided the error of assuming commercial data to be altogether reliable by giving several points of view on disputed topics. The chapters treating of oil insulation fortunately escape such difficulties, paraffin and other oils being free from patents and trade marks, and these will well repay study.

The facility with which oils, spite of the old saying that oil and water will not mix, take up moisture enough to ruin their insulating properties will surprise the non-technical reader and suggests an interesting and useful field of research.

As a bit of friendly criticism it should be suggested that in the next edition most of the experimental curves given should be remade by the wax process, in the interest of neatness and easy reference. A very useful bibliography of the subject is a valuable feature of the book, and the index is satisfactorily full. Altogether Turner and Hobart have done a commendable piece of work and one that will be widely appreciated.

Louis Bell.

Boston.

Grundriss der Soziologie. By Ludwig Gumplowicz. Second edition, revised and enlarged. Vienna, 1905.

Sociologists in this country will be interested in this new edition of Doctor Gumplowicz's famous work. In the preface he calls attention to the rapid development of sociological study during the last twenty years, in which development he modestly hints that his 'Grundriss' might well assert, Quorum pars magna fui.

The text of the first edition is preserved intact, with slight verbal changes here and there. The chief modifications consist in additions, reference notes and quotations from later works. In book one, for instance, the history of sociology is brought down to date. Special attention is given in this to the views of Ratzenhofer, whose untimely death while homeward bound from the congress at St. Louis, deprived sociology of one of its foremost writers. Ratzenhofer's 'Positive Ethik' is extensively quoted from in book four, pages 330–336. Discussions of 'Methode der Soziologie,' and 'Geschichtsphilosophische Konstruktionen,' complete the list of important additions.

This last discussion should be read in connection with his article in *American Journal of Sociology,* March, 1905, entitled 'An Austrian Appreciation of Lester F. Ward.' Dr. Gumplowicz frankly admits that he is not yet prepared to believe in the possibility of an 'applied sociology,' but, while still holding to

the position he set forth in his first edition, he is prepared to see his argument become old-fashioned (hinfällig), with advance in sociological knowledge.

The author has lost none of his old-time vigor of expression, nor of his opposition to the 'organic theory.' He takes occasion to give this latter some hard blows, even though his conclusion is, "Diese 'Methode' ist ein für allemal abgetan," page 170.

J. Q. DEALEY.

BROWN UNIVERSITY,
September 12, 1905.

DISCUSSION AND CORRESPONDENCE.

BREEDING BENEFICIAL INSECTS.

Harper's Monthly Magazine is a journal of such high standing and is as a rule so clean and so accurate that anything published in its pages, aside from ostensible fiction, is received by a very large reading public as bearing the stamp of absolute accuracy. It, therefore, becomes necessary whenever an inaccurate statement is published in its pages, and particularly when by such a statement a keen injustice is done to an institution or to an individual, to publish in some way and as speedily as possible an emphatic rejoinder and correction. I, therefore, wish to call attention to the article by H. A. Crafts in the October number of *Harper's Magazine*, pages 778 to 782, which bears the title of this present communication. The article refers to the excellent work which has been done in California in the breeding of beneficial insects, and more especially to the admirable quarantine carried on by that state against the possible importation of new insect pests. To these features of the article no exception can be taken, but there is another and important matter which must be corrected.

Mr. Crafts writes:

> Mr. Craw [Alexander Craw, late Horticultural Quarantine Officer of California] advised that search be made in foreign countries for the parasite that would destroy the 'cottony cushion-scale.' At that time the state had enacted no horticultural laws, and there were no public funds available for the prosecution of the search suggested by Mr. Craw. But to remedy this defect private funds were raised, and Professor Albert Koebele, an attaché of the United States Department of Agriculture, was commissioned to make the quest.
>
> Professor Koebele in the course of his travels went to Australia, where he found a grub feeding upon the cottony cushion-scale. He took the grub and developed it to its condition of maturity, and found that it grew into a small beetle known as a 'ladybird.' At the same time the professor made a second discovery, and that was that a secondary parasite was preying upon the 'ladybird.'
>
> Knowing that it would be fatal to the project to send the ladybird and its parasite to California together, he set about propagating a colony of the little beetles in close confinement. He accordingly had glass-houses built over two small orange-trees in an orchard that was infested with the cottony cushion-scale, and beneath these he bred up some strong colonies of the ladybirds and sent them to Mr. Craw.
>
> Upon their arrival in California the process of propagation was continued and a large number of the bugs raised. * * *
>
> The insects thus raised by Mr. Craw were sent out in small colonies all over the state wherever there was an orange or lemon orchard affected by the cottony cushion-scale and turned loose in the trees. The result was the speedy cleaning up of the pest, and it has remained in subjection ever since. And thus the great citrus-fruit industry of California was saved.

In these statements Mr. Crafts has done a great injustice to the United States Department of Agriculture, and to the late C. V. Riley, at that time (1888–90) chief entomologist of the department. The facts briefly are these. Prior to the Australian expedition of Mr. Koebele, Professor Riley was in California. He attended, with Mr. Craw, a large horticultural meeting, and the subject of sending abroad for parasites was broached at this meeting. It is quite possible that Professor Riley got the original idea from Mr. Craw. Here, however, Mr. Craw's connection with the introduction ceases; nor do I think Mr. Craw has ever made any personal claim which would in any further way substantiate the statements made by Mr. Crafts, just quoted. Professor Riley returned to Washington, corresponded with entomologists in Australia,

but was unable to devote funds from his appropriation to send an assistant to Australia, for the reason that congress at that time restricted travel to the limits of the United States. There was an exposition that year in Melbourne, and he, therefore, called upon the late Thomas F. Bayard, at that time secretary of state, and urged that the traveling expenses of an assistant be paid, for this purpose, from the funds set aside for the exhibition by the United States at the Melbourne exposition, and of which the Department of State had control. His request was granted, and Mr. Albert Koebele, an assistant in the Division of Entomology, was sent over, his expenses simply being paid by the Department of State and his salary by the Department of Agriculture. Mr. Koebele secured the ladybirds, and in the meantime another agent of the Department of Agriculture, Mr. D. W. Coquillett, stationed at Los Angeles, Calif., had prepared a gauze tent over an infested orange tree. All of Mr. Koebele's shipments were sent direct to this assistant of the division of entomology, and not to Mr. Craw. It was at the Los Angeles station of the division that the insects were propagated, and from which they were sent, and not until considerably later did Mr. Craw, as an agent of the state board of horticulture, have anything to do with the matter. When he did take it up, however, he prosecuted the work very successfully, and during the remainder of his term of office (he is now in the employ of the territorial government of Hawaii) he did a great and good work with other beneficial insects. Thus it will be seen that the introduction and establishment of the ladybirds were done by Professor Riley's assistants, the expenses of Koebele to Australia being paid by the Deparment of State.

It so happened that one of the United States commissioners to the Melbourne exposition was the late Frank McCoppin, and Mr. McCoppin also recommended that the funds for Mr. Koebele's expenses be paid by the Department of State. Mr. McCoppin always claimed, in his lifetime, the full credit for the whole thing, but the facts are as I have stated, and they are within my immediate knowledge, since at the time I was first assistant to Professor Riley and was intimately acquainted with everything that was going on.

The introduction of this insect was one of Riley's greatest achievements, since it established a principle upon which much good work has since been done in many parts of the world; and it should be stated to his further credit that he was sanguine of success at the start, and that the work was carried through against the predictions of his two oldest assistants, Mr. E. A. Schwarz and myself, both of us having urged against the probability of the establishment in the nearctic life zone of an insect belonging to the Australasian fauna.

To Mr. Craw, therefore, belongs the credit of being, if not the original suggester of the plan, at least one of the first suggesters, and also the credit of having, some time after the introduction and perfect establishment of the insect, had charge of its propagation. To Mr. McCoppin belongs only the credit of having facilitated Mr. Koebele's work by recommending that his expenses be paid from the Melbourne exposition fund. To Riley and the Department of Agriculture belongs the credit of having, by investigations, shown exactly the spot to go for the supposed beneficial insects; for having furnished the man to go to Australia, and having paid his salary; for having induced wholly or partially the secretary of state to consent to the payment of the traveling expenses from the Melbourne exposition fund; for the preparations for the receipt of the beneficial insects at Los Angeles; and for having cared for them and supervised their establishment, propagation and distribution for many months after arrival, thus bringing about the wonderful results which followed.

L. O. Howard.

NOMENCLATURE AT THE INTERNATIONAL BOTANICAL CONGRESS AT VIENNA.

To the Editor of Science: I have read with much interest Dr. Britton's account in your issue for August 18 of the action in regard to nomenclature taken at the recent International Botanical Congress at Vienna. So far so good. The action seems to have been about what was expected by most Amer-

ican botanists. The failure to recognize the basic principle of generic types, and the absurd recommendation to make exceptions from the rules adopted in the case of over 400 generic names, make it morally certain that these rules will not be final and will not settle the vexed question of nomenclature. It also seems morally certain that these rules will not be even temporarily accepted by the majority of American systematic botanists. I have read Dr. Britton's paper carefully in the hope that I could find either in or between the lines some hint of the position that he, as chairman of the American Nomenclature Commission, intends to take with reference to these really extraordinary rules. I confess, however, that his purpose has been well veiled. The question is one of such immediate interest and importance in view of the publication of the new 'Flora of North America' that I venture to ask for an expression of his views in your columns as to what shall be done next. For my own part I am free to express the opinion that any attempt to conform to the Vienna rules would be most unfortunate and would only serve to postpone still farther the much-desired attainment of practical stability in the use of plant names.

Fortunately for those of us who are interested in the lower cryptogams, the congress has saved us from the necessity of breaking its rules. If it had confessed its incapacity in regard to the higher plants as well, the situation would be far simpler.

F. S. EARLE.

SANTIAGO DE LAS VEGAS, CUBA,
September 7, 1905.

'CLON' VERSUS 'CLONE.'

I RECUR to this subject merely to correct the misunderstanding under which Professor Eastman labors, as shown in his recent communication to SCIENCE (XXII., p. 206). In my note setting forth the reasons for preferring the spelling *clone*, I did not state the chief fact on which the argument was based, inasmuch as I assumed that any one interested in the subject would undoubtedly consult Mr. Webber's article,[1] in which the word was originally published. Let it be clearly understood, therefore, that viewed in the abstract, one spelling is as good as another, and Professor Eastman's reasons for preferring *clon* would be quite cogent if it were not for the fact that Mr. Webber expressly states that the word is to be *pronounced* with the long sound of *o*. This being the case, I think no one will venture to dispute the point I have already made, that by the requirements of English speech it must be written *clone* or treated purely as a transliteration from the Greek and written *clōn* (preferably *klōn*). Every one of the examples adduced by Professor Eastman (eon, pæon, autochthon, halcyon) affords proof of this, as they are all pronounced with a short *o*. It is quite true, as Professor Eastman states, that 'linguistic usage does not require that loan words and derivatives from other languages should always preserve the same vowel quantities.' But it does require that if the vowel quantity is to be definitely indicated in pronunciation, as Mr. Webber desires in the case of this word, it must be also indicated by the orthography or by some graphic mark of quantity. Hence the word must be treated lexicographically as either *clōn* or *clone*. If written simply *clon*, everyone would be justified in pronouncing it *clŏn*.

CHARLES LOUIS POLLARD.

SPRINGFIELD, MASS.

[1] SCIENCE, XVIII., 501–503, 1903.

SPECIAL ARTICLES.

A DIAGRAM OR CHART FOR FINDING THE SUN'S AZIMUTH.

IN SCIENCE for July 24, 1903, under the title 'On Uses of a Drawing Board and Scales in Trigonometry and Navigation,' I have briefly described such simple apparatus as seemed to be most serviceable in the solution of spherical triangles. What is written here may be regarded as a continuation of that article, because the apparatus there described can be used in place of the azimuth diagram and in ways quite analogous to those here outlined.

Given two sides of a spherical triangle and the included angle, to find one of the remaining angles without first finding the side op-

posite the given angle. Let b, c and A denote the given parts and C the required angle. From the fundamental equations

$$\cos a = \cos b \cos c + \sin b \sin c \cos A, \quad (1)$$
$$\cos c = \cos a \cos b + \sin a \sin b \cos C, \quad (2)$$
$$\sin C \sin a = \sin A \sin c, \quad (3)$$

the quantity a may be eliminated by first dividing (1) by (3), then (2) by (3) with its members interchanged, and then comparing these results. After reducing to a simple form, there results the well-known equation

$$\sin A \cot C = \sin b \cot c - \cos A \cos b. \quad (4)$$

If we write

$$x = \cos A \cos b \sin c - \sin b \cos c, \quad (5)$$
$$y = \sin A \sin c, \quad (6)$$

then

$$\frac{x}{y} = -\cot C, \quad \frac{y}{x} = -\tan C. \quad (7)$$

Since we are here concerned only with the ratio of x and y it is convenient to write

$$x = \cos A \cos b - \sin b \cot c, \quad (8)$$
$$y = \sin A, \quad (9)$$

provided $\cot c$ does not become too great, and the ratio x/y or y/x will remain as before.

center. A system of straight lines radiate from the common center of the semicircular arcs. The angles formed by these lines and the initial line are written in the margin of the diagram. Although not shown in the sketch, the entire diagram is covered by systems of horizontal and vertical lines differing in color or character from the lines already referred to. The entire sheet is thus divided into small squares, the purpose being to enable one to work accurately even if the paper should become somewhat distorted and also to work without marking up the permanent diagram.

If we locate the point x, y upon the azimuth diagram, then by (7) the angle at the center which this point makes with the direction $-x$ is the angle C.

The product $\sin b \cot c$ of (8) is positive or negative according as c lies between 0° and 90° or 90° and 180°. Its numerical value is the horizontal distance from the central vertical line, measured on a level with the vertex of the circle whose radius is $\sin b$, to the radiating line numbered c.

Upon the radiating line which makes the angle A with the initial direction, mark two

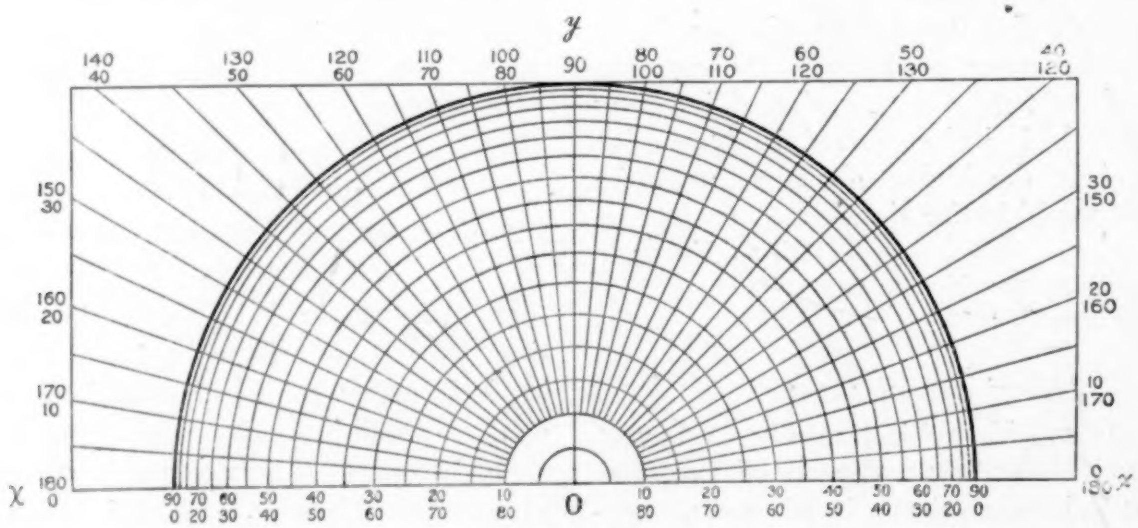

FIG. 1.

The azimuth diagram or chart may be described by aid of a sketch, Fig. 1. The radii of the system of concentric semicircles are equal to $\sin \theta$ where θ varies from 0° to 90°, counting from the center, or to $\cos \theta$ where θ varies from 0° to 90°, counting towards the

points, one where it crosses the outer circle and one where it crosses the circle whose radius is $\cos b$. Follow the horizontal and vertical straight lines until a point is found on a level with the first point and on the vertical passing through the second point.

Go from this point in a horizontal direction the distance $-\sin b \cot c$. The point thus located is x, y.

When b is greater than 90°, solve the triangle whose given parts are $A, b' = 180° - b$, and $c' = 180° - c$.

Given the latitude of the place and the declination of the sun, to find the true azimuth of the sun at any given apparent time.

Let λ denote the latitude of the place and δ the declination of the sun, north declination being regarded as positive. The product $\cos\lambda \tan\delta$ is positive for north declination and negative for south. Its numerical value is the vertical distance from the horizontal initial line, measured along the vertical line which is distant $\cos\lambda$ from the central line, to the radiating line numbered δ.

Upon the radiating line which makes the (hour) angle A with the initial direction $(+x)$, mark two points, one where it crosses the outer circle, the other where it crosses the circle whose radius is $\sin\lambda$; see Fig. 2. Follow the horizontal and vertical straight lines until a point is found on a level with the first point and on the vertical passing through the second. Go from this point in a horizontal direction the distance $\pm \cos\lambda \tan\delta$, and so locate a fourth point (x, y). The angle at the center between the direction $-x$ and this point is the sun's true azimuth (C) from the north in the northern hemisphere and from the south in the southern. In Fig. 2 as drawn $A = 45° = 3$ hours; $\lambda = 40°$ N.; $\delta = 20°$ N.; $C = 103° 57'$, showing that the azimuth of the sun is then $103° 57'$ from the north or $76° 3'$ from the south.

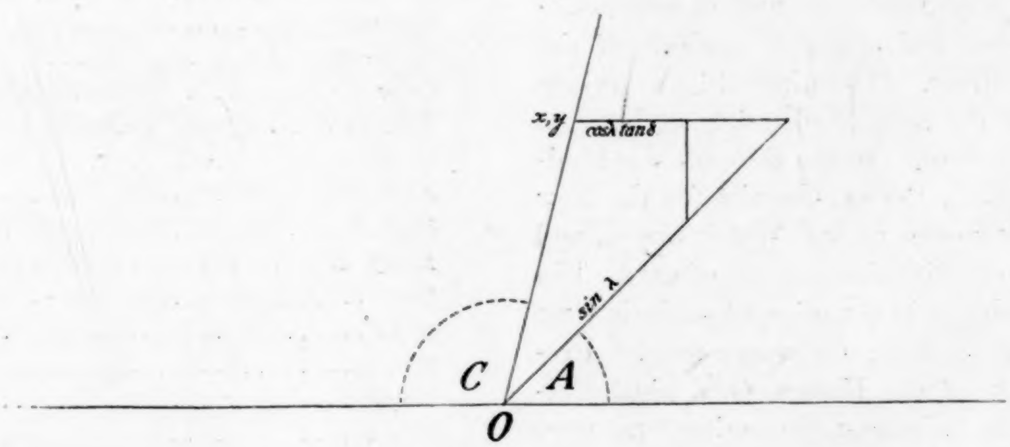

Fig. 2.

A rectangular sheet of waste paper facilitates the determination of the product $\cos\lambda \tan\delta$ and the application of this quantity to locating the point x, y.

If while making a survey λ and δ be regarded as constant, the azimuth of the sun at any given hour and minute can be obtained with great facility.

The uses of the azimuth diagram in great circle sailing and in cartography are too obvious to require comment.

Experience shows that if the radius of the outer circle of the diagram is 16⅜ inches and the circles and the radiating lines go by half degrees, the azimuth under reasonably favorable conditions can easily be found to within about three minutes of its true value.

It is obvious that if two of the three given parts of a triangle are opposites, the unknown part opposite the third given part can readily be ascertained by means of the diagram, because all such products as $\sin C \sin a$, or $\sin A \sin c$, or $\sin A \sin b$ are thereon represented. Such solutions of right-angled triangles as involve only sine or cosine factors can therefore be obtained.

If the x and y of (8) and (9) can not be used on account of the term involving a cotangent, the required angle can still be determined by aid of the diagram, although not as easily as before, because equations (5) and (6) are more complicated than are equations (8) and (9).

The diagram enables one to find such products as those involved in equation (4), and so a graphic solution of this equation as it stands can be carried out if desired.

Since the radiating lines cut the lines $x = \pm 1$ and $y = 1$ in scales of tangents and cotangents, such products as cot b tan c, if the factors are not too great, can be obtained by first finding cot b in the upper margin of the diagram and then going downward (keeping at a distance cot b from the central line) until meeting the radiating line numbered c. The distance thence to the initial or base line is cot b tan c. The cosine scale of the diagram enables one to find the angle whose cosine is equivalent to cot b tan c. This is the angle A of a spherical triangle right-angled at B. R. A. Harris.

ANALYSIS OF THE MISSISSIPPI RIVER.

A short time ago, in conversation with Dr. E. W. Hilgard, of the University of California, I learned, to my great astonishment, that he had been unable to find in any publication a recent and complete analysis of the Mississippi River. Deeming this a serious oversight on the part of chemists at large, a sample was secured for me through the kindness of Mr. J. L. Porter, chemist for the New Orleans City Sewerage and Water Board, and analyzed by me with the greatest of care. The methods employed in the mineral analysis were very similar to those recommended by Professor Bailey, of the Kansas Geological Survey, while the nitrogen determinations were patterned after those made by the Massachusetts State Board of Health.

The sample was taken by J. L. Porter, chemist of the New Orleans City Sewerage and Water Board about noon of May 23, 1905. Location of the sample was opposite Nine Mile point just above Carrollton, in midstream, and about six feet below the surface. Temperature of the water at the time was 23° C. Turbidity was about twice the average for the year. Oxygen was about one hundred per cent. of saturation and the free carbonic acid about three parts per hundred thousand.

The results of the analysis are as follows:

Results of Analysis Expressed in Parts per 100,000.

Total solids (unfiltered)	106.9
Total solids (filtered)	16.75
Loss on ignition (unfiltered)	7.4
Loss on ignition (filtered)	2.75
Si	0.35
Al	0.009
Mn	0.012
Ca	2.95
Mg	0.68
Fe	0.008
K	0.23
Na	1.00
SO_4	2.87
PO_4	0.04
CO_3	0.00
HCO_3	11.04
Cl	1.61
Nitrogen as free ammonia	0.016
Nitrogen as albumenoid ammonia	0.014
Nitrogen as nitrites	0.000
Nitrogen as nitrates	0.023
Oxygen consumed (unfiltered)	1.42
Oxygen consumed (filtered)	0.33
Hardness	10.92
Turbidity	Heavy.
Sediment	Large.
Odor (cold)	Practically none.

Results of Analysis Calculated as Oxides.

SiO_2	0.74
Al_2O_3	0.017
Fe_2O_3	0.011
Mn_3O_4	0.016
CaO	4.12
MgO	1.13
K_2O	0.28
Na_2O	1.35
SO_3	2.39
CO_2	7.96

The silica was rather higher than I expected, being about the same as that found in the Hot Springs of Arkansas by Mr. Haywood. Still, it is not a quarter of that occurring in many of our western streams. The ratio of lime to magnesia is about normal, as is the ratio of Na_2O to K_2O, but the amount of bicarbonate seems unusually large, indicating a large percentage of drainage from the arid lands to the northwest. Sulphates form a rather large per cent. of the total solids, but this also is to be expected when we consider

the drainage area from which the river is fed. The nitrates are a little higher than is usual in May, but the free and albumenoid ammonias compare very well with the results obtained by the New Orleans City Sewerage and Water Board. The silt varies very largely from month to month, hence no reliable conclusion can be drawn from any one analysis. This silt was saved and will be subjected to a plant food analysis at a later date.

In conclusion, let me say that this analysis has, to my mind, demonstrated the desirability of a very complete and detailed chemical study, month by month, of the Mississippi River and its tributaries, and I should have undertaken such a study personally had I not learned that it was already planned for by Mr. M. O. Leighton, in charge of the Division of Hydro-economics, U. S. Geological Survey.

C. H. Stone.

U. S. Geological Survey,
Reclamation Service Laboratory.

FUNCTIONS OF A TRANSPLANTED KIDNEY.

The state of the circulation and of the secretion of a transplanted kidney has been observed on an animal operated on in this laboratory. A careful investigation of the literature has revealed no mention of a similar experiment having been performed hitherto.

The kidney of a small-sized dog was extirpated and transplanted into the neck. The renal artery was united to the carotid artery, the renal vein to the external jugular vein and the ureter to the œsophagus. Three days after the operation the neck and the abdomen were opened, in order to study the functions of the transplanted kidney and to compare them with the functions of the normal kidney. The transplanted kidney was found adherent to the muscles, and dissection was necessary to free it. In size it was larger than the normal kidney. Its hue was darker. To the touch the consistency of its tissue was normal, and the pulsations of its artery were as strong as the pulsations of the artery of the normal kidney.

Here is the summary of this observation: *the circulation in the transplanted kidney* was slightly greater than in the normal kidney, as detected by the touch, copiousness of hemorrhage from incision in cortex, and pulse-tracings.

The secretion of urine by the transplanted kidney was about five times more rapid than by the normal one. The intravenous injection of sodium chloride solution caused no change in the rate of secretion in the normal, but markedly increased the rate of the secretion in the transplanted organ.

The composition of urine secreted by the transplanted kidney differed somewhat from that secreted by the normal one. The constituents were similar, but the chlorides appeared to be more abundant in the urine from the transplanted kidney, while the organic sulphates, pigments and urea were more abundant in the urine from the normal organ.

Alexis Carrel,
C. C. Guthrie.

The Hull Physiological Laboratory,
University of Chicago.

THE UNIVERSITY OF FLORIDA.

The state legislature of Florida during its recent session, April 4 to June 2 of the present year, enacted a measure, commonly known as the 'Buckman Bill' designed by its originators to consolidate and strengthen, and to economize in the running expenses of the educational system of the state. By the provisions of the bill the entire system of higher education, consisting of a state university, a girls' college, and including the normal school for colored students and the institute for the deaf and blind, is under the management of a single board of control of five members appointed by the governor from five sections of the state. By the terms of the bill existing state schools are abolished as follows: The University of Florida, Lake City; Florida State College, Tallahassee; Normal School, DeFuniac Springs; East Florida Seminary, Gainsville; South Florida College, Bartow; Florida Agricultural Institute, Osceola County; and the Normal and Industrial department maintained by the state in the St. Petersburg Normal and Industrial School. To replace these abolished institutions there is created a University of the State of Florida

and a State College for Girls. It is required that the university be located at some central point in the state, both geographically and as to population, and with due consideration for the lands, grounds and buildings already in the possession of the state; and that the girls' college be located on the site of some one of the abolished institutions. The actual selecting of sites for these two institutions is left in the hands of the board of control in joint action with the state board of education. The organization and future management of the two institutions is left to the board of control, subject to the approval of the board of education.

Both institutions have been organized and it is announced that they will open to receive students on September 27. The girls' college has been located at Tallahassee, on the site of the former Florida State College. The city of Gainsville was selected by the boards in joint session as the permanent location of the university. It has been decided, however, that the new university shall continue on the site of the abolished university for one year, or until the grounds at Gainsville are ready for its reception.

The state university, as established, consists of: A department of agriculture, mechanical and industrial arts; a science and classical department; a normal department; and 'such other departments as may from time to time be determined upon and added at any joint meeting of the state board of education with the board of control.' The state experiment station retains its connection with the university.

The Buckman bill carries an appropriation of $150,000 for the maintenance of the four institutions under the management of the board of control for the ensuing two years. The city of Gainsville has donated a tract of five hundred acres of land as a site for the university and experiment station, and $40,000 to be used in the erection of buildings, and has offered $30,000 to the state for the buildings formerly occupied by the East Florida Seminary. The agricultural department and the experiment station receive the benefit of the government funds accruing to them from the Morrill and Hatch acts.

Dr. Andrew Sledd, Randolph-Macon College, Harvard and Yale Universities, and president of the former University of Florida, has been secured as president. The heads of the science departments, all of whom occupied their respective positions in the abolished University of Florida, are as follows: Edward R. Flint, Massachusetts Agricultural College and Göttingen, chemistry; Karl Schmitt, Berlin and Marburg, mathematics; C. M. Connor, Michigan Agricultural College and University of Missouri, agriculture; F. M. Rolfs, Iowa State College and Colorado Agricultural College, botany and horticulture; M. T. Hochstrasser, Georgia School of Technology, mechanical engineering; J. R. Benton, Trinity College and Göttingen, physics and civil engineering; E. H. Sellards, University of Kansas and Yale University, zoology and geology.

STATIONS FOR THE DETERMINATION OF THE VARIATIONS OF LATITUDE.

SINCE the plan to make observations to determine the variations of latitude in the southern hemisphere in addition to those being made in the northern hemisphere was announced in SCIENCE, the Central Bureau of the International Geodetic Association has definitely selected the two stations to be occupied and the observations will begin on January 1, 1906.

One station is in South America, at Oncativo, a village in the Argentine Republic, on the Argentine Central Railway, 72 kilometers from Cordova and 622 kilometers from Buenos Ayres. It is located on a plain with favorable topographic and climatic conditions. The temperature ranges from $-6°$ to $+40°$ (Centigrade) and the mean cloudiness during the year is expressed by 4 on the customary scale. The rainy season occurs in summer, when the rainfall amounts to 700 mm. Dr. Luigi Carnera has been appointed observer.

The other station is in Australia, at Bayswater, a town 6 kilometers northeast of Perth, the capital of West Australia. There the annual range of temperature is between 0°

and $+40°$ and the mean cloudiness varies from 2 in summer to 5 in winter. The annual rainfall amounts to 870 mm. Dr. Curt Hessen will be in charge of the observatory.

Both these stations are in latitude $-31°$ 55′.

At the Observatory of Pulkowa, in latitude $+59°$ 46′, a series of observations is in progress to supplement the observations at the stations of the International Geodetic Association and it is expected that the observatories at Leyden (latitude $+52°$ 09′) and at Tokyo (latitude $+35°$ 39′) will cooperate in this work.

PROFESSOR BJERKNES'S LECTURES.

THE lectures which Professor V. F. K. Bjerknes, of the University of Stockholm, will give at Columbia University during December are as follows:

FIELDS OF FORCE.

Friday, December 1, 1905, 4 to 6 P.M.: 'Elementary Investigation of the Geometric Properties of Hydrodynamic Fields' (with experiments).

Saturday, December 2, 1905, 10 to 12 A.M.: 'Elementary Investigation of the Geometric Properties of Hydrodynamic Fields' (with experiments).

Friday, December 8, 1905, 4 to 6 P.M.: 'Geometric Properties of Electromagnetic Fields According to Maxwell's Theory.'

Saturday, December 9, 1905, 10 to 12 A.M.: 'The Dynamic Properties of Electromagnetic Fields according to Maxwell's Theory.'

Friday, December 15, 1905, 4 to 6 P.M.: 'Transformation of the Hydrodynamic Equations to Forms which prove the Analogy of Hydrodynamic and Stationary Electromagnetic Fields.'

Saturday, December 16, 1905, 10 to 12 A.M.: 'Further Development and Discussion of the above Analogy.'

Friday, December 22, 1905, 4 to 6 P.M.: 'General Conclusions: Remarks on Methods of Research and of Instruction in Theoretical Physics.'

Saturday, December 23, 1905, 10 to 12 A.M.: 'Supplementary Lecture: The Hydrodynamic Fields of Force in the Atmosphere and the Sea; Discussion of the Fundamental Problem of Meteorology and Hydrography.'

The lectures will be open without charge to teachers and advanced students of physics.

PERMIAN GLACIATION IN SOUTH AFRICA.

THE following note of greeting has been addressed to Professor T. C. Chamberlin, of the Unversity of Chicago:

Members and guests of the British Association in South Africa, returning from a geological excursion, provided by the hospitality of the Natal government, send you greetings and wish you might have been with us to-day to see the Dwyka glacial formation (Permian) lying on a glaciated surface of Barberton (Archæan?) beds. The evidence of extensive glaciation, with *southward* movement of the vast ice sheet, is not to be doubted.

J. LOMAS, Liverpool.
G. N. MOLENGRAAFF, Johannesburg.
A. PENCK, Vienna.
B. HOBSON, Manchester.
DR. PR. BECK, Freiberg.
WILLIAM ANDERSON, Natal.
A. P. COLEMAN, Toronto.
F. G. KATZENSTEIN, Vryheid, Natal.
W. M. DAVIS, Cambridge, Mass.

VRYHEID, DISTR. NATAL,
Aug. 26, 1905.

SCIENTIFIC NOTES AND NEWS.

WE regret to learn that the condition of Dr. William R. Harper, president of the University of Chicago, is now very serious.

PROFESSOR EBERTH, director of the Pathological Institute in Halle and discoverer of the bacillus of typhoid fever, celebrated his seventieth birthday on September 21.

PROFESSOR FRANKLIN C. ROBINSON, head of the department of chemistry of Bowdoin College, has been elected president of the American Public Health Association, which will hold its annual meeting in January in the city of Mexico.

PROFESSOR WILHELM OSTWALD, of Leipzig, who, as we have already announced, will give courses in physical chemistry and philosophy at Harvard University during the first half of the present academic year, arrived at Cambridge on the second instant.

PROFESSOR J. A. HOLMES, of the University of North Carolina, is in Germany to investigate for the U. S. Geological Survey the use of brown lignite bricquettes for fuel and methods of protecting railway ties.

DR. WYSSLING, professor of electrical engineering in the Polytechnic Institute at Zurich, and Charles Wirth, also of Zurich, are in this country, to prepare a report on electrical railway development for the Swiss government.

THE opening address to the students of the medical faculty of McGill University was delivered, on September 19, by Dr. Abraham Jacobi, emeritus professor at Columbia University. In the evening he was the guest of honor at a banquet.

DURING the coming January Mr. Bailey Willis, of the United States Geological Survey and the Carnegie Institution, will present a course of twelve lectures in the geological department of the University of Wisconsin on the subject of 'Continental Variations, with Special Reference to North America.'

MR. E. E. ELLIS has recently completed for the Division of Hydrology, U. S. Geological Survey, an investigation of the occurrence of groundwater in crystalline rocks of Connecticut. The results show that the supplies to be obtained from such rocks are much greater than is usually supposed, that the water is frequently under artesian pressure, and that its occurrence has a very definite relation to the presence of overlying drift.

MR. CARL SCHAEFFER has just returned from southwestern Arizona, where he has been collecting insects for the last three months in the interest of the Museum of the Brooklyn Institute. His trip has been very successful and he has obtained many rare and some new species, the beetles being represented by the largest number of species and specimens. He secured a few specimens of the very rare tiger beetle, *Amblychila heroni*, only three or four specimens of which were previously known in collections. A few specimens of *Gymnetes cretacea*, were secured and two other species of the same genus new to the fauna of the United States. The collection of moths includes a number of rare species, some being heretofore represented by a single specimen and some that have recently been thrown out of lists, having been considered as wrongly attributed to our fauna. As soon as time permits, the material will be worked up and the results published.

THE house at Ithaca occupied by the late Professor R. H. Thurston has been purchased by Mr. Hiram W. Sibley and given to the university as a residence for the director of Sibley College.

PROFESSOR DEWITT BRISTOL BRACE, Ph.D. (Berlin), head of the department of physics in the University of Nebraska, and one of the leading physicists of the United States, died at his home in Lincoln, Nebr., on October 2, at 2 o'clock in the afternoon. He was in his forty-seventh year, and had just entered upon his nineteenth year of teaching in the University of Nebraska.

BARON FERDINAND VON RICHTHOFEN, professor of geography in the University of Berlin, died on October 7, at the age of seventy-two years.

THE death is also announced of Mr. George Bowdler Buckton, F.R.S., a leading British entomologist.

THE International Tuberculosis Congress will hold its next meeting in Washington in 1908. At the closing session of the Paris Congress, on October 7, Professor Behring made a statement relative to his new curative principle for tuberculosis. According to a cablegram published in the daily papers he said: "In the course of the last two years I recognized with certainty the existence of a curative principle completely different from the antitoxic principle. This new curative principle plays an essential rôle in the operation of the immunity derived from my bovovaccine, which has proved effective against animal tuberculosis during the past four years. This curative principle reposes upon the impregnation of the living cells of the organism with a substance originating from tuberculose virus, which substance I designate 'T. C.'" Professor Behring then gave a technical description of how 'T. C.' was introduced into the cellular organism, and said it had already given marked results in the treatment of animals. He expressed the confident belief that his researches would permit similar curative results in man. He added that he was unable

to say how soon positive results would be obtainable, but he felt as certain that these results would be attained as when he first announced his discovery of a new method for treating diphtheria.

THE conference of the International Union for Cooperation in Solar Research was concluded on September 29, in New College, Oxford. It was resolved to accept the invitation of M. Janssen to meet at Meudon in September, 1907. Professors Schuster (chairman) and Hale were elected members of the executive committee. It was decided that the central bureau should be at the University of Manchester, and that the computing bureau should be at the University Observatory, Oxford, under the direction of Professor Turner. Committees were elected to deal with the following four subjects: (1) Standards of wavelength; (2) solar radiation; (3) cooperation in work with the spectro-heliograph; (4) cooperation in work on the spectra of sun-spots.

THERE will be a New York state civil service examination on October 28, to fill the position of assistant in botany in the science division of the Education Department with a salary of $600, for assistant in microscopy in the Buffalo Cancer Laboratory with a salary of $720, and of Bertillon clerk in the state prison with a salary of $900.

THE *Vingtième Siècle,* according to a Reuter telegram from Brussels, announces that, upon the initiative of the king of the Belgians, the polar explorers MM. Lecointe and Arktovski, of the *Belgica* expedition, Professor Nordenskiöld and Messrs. Bruce and Shackleton had a meeting after the sitting of the Mons Congress. The result of their deliberations was that a scheme for international expeditions to the North and South Poles was to be laid before the fifth section of the congress. It is proposed that these expeditions shall be organized through the good offices of the various governments interested in the scheme, and that monster subscriptions shall be opened for the purpose. The government of the king of the Belgians will play a great part in the organization of the expeditions. The polar explorers Sverdrup and Nansen (Norway), the Duke of the Abruzzi (Italy), Von Drygalski (Germany), Charcot (France), De Gerlache and Rakovitza (Belgium) and Cook and Peary (United States), who had been summoned to the meeting, were prevented from attending, but they wrote offering their support to the enterprise. Numerous subscriptions have already been received. A Reuter telegram from Mons states that the fifth section of the Congress on Polar Exploration has unanimously adopted a resolution in favor of the scheme.

The New York Medical Record states that the department of agriculture of the University of California has been engaged for several years in the study of the diseases of the insects that destroy various crops in this and other states, and in several instances have met with great success. Since July, Professor Clarke, assistant entomologist, had been studying a bacterial disease that completely exterminated the grasshoppers at Los Banos. The disease was of unknown origin and in the course of a month destroyed a countless army of the insects, after they had entirely devoured the alfalfa crop.

THE outlook for a profitable mining industry in the Philippine Islands is more hopeful to-day than it has been at any time since the American occupation, according to a brief report written by Mr. H. D. McCaskey, chief of the Mining Bureau, Philippine Islands, and published as an extract from the annual volume of the United States Geological Survey entitled 'Mineral Resources of the United States, 1904.' Mining development is now carried on in the provinces of Lepanto-Bontoc, Benguet, Pangasinan, Nueva Ecija, Bulacan, Rizal, Batangas, Tayabas, Camarines, Albay, Masbate, Cebu and Mindanao, and prospecting is being done in almost every island and province of the archipelago.

THE approaching session of the Royal Geographical Society, under the auspices of the new president, Sir George Goldie, promises, says the London *Times,* to be a busy one. It begins a week earlier than usual, and there will be four ordinary meetings before Christmas. The first meeting will be held on November 6, when the president will make a few introductory remarks, to be followed by a

paper on the mountains of Central Japan, by the Rev. Walter Weston. At the meeting on November 20, Mrs. Fanny Bullock Workman will give an account of the first exploration by herself and her husband of the Hoh-Lumba and Lobson glaciers, in the western Himalayas. On December 4, Mr. H. Weld Blundell will give a paper on the very interesting investigations he has been making on the Abai basin, in Abyssinia. On December 18, Mr. C. G. Seligman will give an account of the recent expedition to British New Guinea, under Major Daniels; the paper will be illustrated with cinematograph slides showing after a vivid fashion some of the customs of the natives. Among papers to be expected after Christmas are the following: 'Unexplored India,' by Colonel Sir T. H. Holdich; 'The Economic Geography of Australia,' by Professor J. W. Gregory, F.R.S.; 'Survey and Exploration in Seistan,' by Colonel A. H. McMahon, C.S.I.; 'Exploration in Tierra del Fuego,' by Captain R. Crawshay; 'Exploration in the East Tibet Borderlands,' by Lieutenant Filchner; 'Explorations in Bolivia and Peru,' by Baron E. Nordenskjöld; 'The Philippine Islands,' by Professor Alleyne Ireland; 'Northern Rhodesia,' by L. A. Wallace; 'The Geographical Influence of Water Plants in Chile,' by G. F. Scott Elliot; 'Maps of London,' by Laurence Gomme. Major St. Hill Gibbons will give a paper dealing with some of the results of his recent expedition to British East Africa in connection with the Zionist Association, and a paper on 'The Geography of the Spanish Armada' may be expected from the Rev. W. Spotswood Green. In addition to the ordinary evening meetings of the society, the research department, instituted about two years ago, holds frequent afternoon meetings for the discussion of special subjects in scientific and applied geography. The scheme for the investigation of the changes which have taken place in the North Sea Coast region during historical times will be further considered, and it is hoped active steps will be instituted for carrying out the inquiry. Sir Clements Markham will introduce the question of 'The Next Great Arctic Discovery,' in which he will advocate detailed investigation of the unknown region lying between Prince Patrick Island and the New Siberian Islands. Among other subjects to be brought before this department of the society will be the results of an investigation into the areas of the orographical regions of England and Wales, by Dr. A. J. Herbertson, reader in geography at Oxford University. It is expected that the visit of the British Association to South Africa will have furnished the geographical members with certain problems in their subject suitable for discussion at the research department.

The present is an especially favorable time to study the geologic structure of Greater New York, for never before in the earth's history has there been such a focus for engineering enterprises as is now found within the 50 or more square miles included within Manhattan Island. These enterprises have together furnished more than 35 sections across the rivers which form the water front of the island. Many of them reveal the nature of the subjacent rock, and a number of them give nearly complete section across it. In view of the rapid work of the engineers, it is important that observations be made and recorded at once lest the opportunity be forever lost. Bulletin 270 of the United States Geological Survey, which is entitled 'The Configuration of the Rock Floor of Greater New York,' is, therefore, an especially timely study. Mr. William Herbert Hobbs, the author, calls further attention to the fact that the present is a particularly favorable time for geologic observation in this vicinity, because of the enormous increase in the value of real estate upon Manhattan Island. It is resulting in a paring down of all rock masses which project above the general level in order to make room for business blocks and apartment houses. The greater number of the rock exposures described by Dana and other early observers are now no longer seen, and those still uncovered by blocks and pavements will in a very few years have disappeared from view. After reviewing briefly the structural geologic studies made in the New York City area by earlier writers, Mr. Hobbs states that too little weight, in his opinion, has been ac-

corded by recent observers to the importance of normal faulting in determining the structure of Manhattan Island. He describes a number of additional fault planes which have recently been located. The purpose of his investigation is to determine the depth and the nature of bed rock beneath Greater New York, through the medium of wells and borings, the numerous bridge and tunnel sections, the government dredgings, the reefs in mid-channel, etc. It is believed that this work will aid not only in the solution of the geological problems of the area, but will be of assistance to those engaged in the great engineering enterprises now going forward on the island, as well as to architects, contractors and many others.

THE Iron and Steel Institute of Great Britain met at Sheffield on September 26, when Mr. R. A. Hatfield gave the presidential address. According to the abstract in the London *Times* he dwelt upon the large and important position which Sheffield had taken in the development of steel and its applications. As they all knew, Chaucer in 1460 spoke of Sheffield thwitels, and these still formed a not unimportant branch of Sheffield products. In the interesting works of that important French metallurgist of the eighteenth century, Jars, Sheffield was then recognized as playing a very important part in metallurgy. Sheffield had indeed been the cradle of modern steel industry, and its development had been largely due to the work of Sheffield men. They all knew how much Huntsman did, and it was a special pleasure to see there that day two of his descendants. Coming nearer to their own times, whilst Bessemer was not a Sheffield man, the first practical developments of his process might be truly said to have occurred there, and were carried out by Sheffield men. Sir John Brown, with his great foresight, saw the importance this process would occupy, and his firm turned out some of the highest quality material for rails probably yet produced. He had now in his possession an interesting photograph representing rails and bars rolled by Sir John Brown at the Atlas Works from the first rails made commercially of Bessemer's steel. This photograph had been kindly sent to him by the son of Mr. Bragge, who was then one of Sir John's partners. On it there occurred the following remarkable inscription, personally written by Mr. Bragge forty-four years ago: "This photograph was taken from the first rails ever made commercially in England of cast steel, produced by Bessemer's process, and when steel rails have superseded iron, as they certainly will do in the course of time, this picture will record who first had courage to introduce them to the world. May 1st, 1861." A remarkable prediction which had indeed come to pass. Mr. W. D. Allen, of Bessemer's firm in Sheffield, also largely helped in the practical development of this method of steel making, and the inimitable Holly, from whose work the enormous development of Bessemer steel in America largely arose, did not go to South Wales or elsewhere, but came to Sheffield to be initiated, so that Sheffield might be rightly said to have taught America how to make steel rails used in those lines of communication that had entirely altered the whole face of the vast Transatlantic continent. In the same manner as regards the Siemens's process, firms such as Vickers's were largely instrumental in leading to the more rapid development and perfection of this method of producing steel. Then, too, they saw men such as Mark Firth, William Jessop, Charles Cammell and others who were indeed pioneers, and from whose labors the world to-day found so great benefit. On the scientific side they had, amongst others, Dr. Sorby, who had rendered invaluable service to metallurgy by his initiation, as far back as 1857, of methods of examining the micro-structure of metals, from which they to-day were obtaining much valuable information. To-day Sheffield had probably the largest industrial army of any city devoted to the production and working of steel, 30,000 men or more being so employed. The work done by the institute spoke for itself, and as a sign of prosperity, he might say that they had that day elected something like 150 new members, bringing the roll-call to the satisfactory grand total of no less than 2,200 members.

UNIVERSITY AND EDUCATIONAL NEWS.

Mr. John D. Rockefeller has now paid to the General Education Board the $10,000,000 in accordance with the announcement made last June. The income, it will be remembered, will be distributed to promote a comprehensive system of higher education in the United States, and it is assumed, though perhaps not correctly, that the larger part will be given to the denominational colleges. The secretary of the board is the Rev. Dr. Wallace Butterick, 54 William Street, New York City.

New York University receives $20,000 by the will of the late William A. Wheelock.

The Ontario government has selected the following men to compose a commission to report on the proposed reorganization of the University of Toronto: Professor Goldwin Smith, Sir William Meredith, Byron E. Walker, J. W. Flavelle, the Rev. Canon Cody, the Rev. D. B. Macdonald and A. H. N. Colquhoun. The gathering of information and the preparation of a report for the government to act upon at the next session of the legislature will be begun at once.

The freshman registration of the academic department at Yale University will be about 400, and the registration at the Sheffield Scientific School will be about the same. The growth of the latter school is noteworthy, the freshmen class having about doubled since 1900.

The entering class at the University of Nebraska numbers this year 475, and the total registration will be about three thousand.

As was noted here last week, John M. Tillman, B.L.L., was formally inaugurated president of the University of Arkansas on September 20. The addresses on the occasion were as follows:

J. C. South: 'For the Board of Trustees.'

A. H. Purdue: 'For the Faculty.'

J. C. Marshall: 'For the Alumni.'

W. S. Sutton, University of Texas: 'For a Sister University.'

E. A. McCulloch, Associate Justice Arkansas Supreme Court: 'Introduction of the President.'

President John N. Tillman: 'Inaugural Address.'

At the opening of the present year, Professor Henry S. White formerly of Northwestern University, assumes the duty of professor of mathematics at Vassar College.

W. J. Miller, Ph.D. (Johns Hopkins), has been appointed to succeed Professor C. H. Smyth, Jr., in geology, at Hamilton College, and M. W. Twitchell, Ph.D. (John Hopkins), has been appointed to the chair of geology at South Carolina College, Columbia.

The list of preceptors with the rank of assistant professors appointed under the new preceptorial system at Princeton University has now been made public. There are in all forty-four, all of whom are in languages, philosophy, history and political science, except three in mathematics and one in geology. The appointments in mathematics are L. P. Eisenhart (Princeton), William Gillespie (Princeton) and G. A. Bliss (Missouri), and in geology, Marcus S. Farr, '92 (Princeton).

Dr. Henry Raymond Mussey, of New York University, has been appointed associate professor of economics and politics at Bryn Mawr College in place of Dr. Lindley Miller Keasbey, who has resigned the chair to be head of the department of economics in the University of Texas.

Clark Wissler, Ph.D., and Berthold Laufer, Ph.D., have been appointed lecturers in anthropology at Columbia University.

Mr. E. D. Chase has been added to the teaching force at the Gayley Chemical Laboratory of Lafayette College.

Dr. Roger C. Wells, formerly instructor in Harvard University, has been appointed instructor in physical chemistry at the University of Pennsylvania. Dr. Wells has begun a study of electrical conduction in melted salts.

At Cornell University recent appointments are: E. W. Schoder, assistant professor of experimental hydraulics; C. F. Harding, assistant professor of electrical engineering, and R. M. Robertson, instructor in electrical engineering.

W. C. Sabine, assistant professor of physics at Harvard University, has been promoted to a professorship.